

LA-UR- 01 - 4498

Approved for public release;
distribution is unlimited.

Title: Corrosion of Austenitic Stainless Steel Alloyed with Gallium
for the Evaluation of 3013 Containers - Test Results

Author(s): Rene Chavarria (NMT-15)

Submitted to: General Distribution



Los Alamos

NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

Background

These tests investigate the effect of gallium content on the corrosion behavior of austenitic stainless steel exposed to 3M NaCl. The investigation was carried out in support of the 94-1 core technology program, which examines the long-term (50 years) interim storage of plutonium-bearing material. The material will be stored in nested austenitic stainless steel containers. The inner and outer containers will be fabricated of austenitic stainless steel. A reduction in the useful shelf life of the inner storage containers is a concern. The susceptibility of the storage containers to corrosion, stress corrosion and embrittlement is discussed by Kolman¹.

DOE standard DOE-STD-3013-99 provides guidance for the stabilization, packaging and safe storage of the plutonium-bearing material. The packaged material must contain at least 30 wt% plutonium and yield less than 19W. The material must be stabilized via calcination in air at 950°C. The calcination process will reduce the amount of water present during packaging and volatilize any unstable materials. If the plutonium-bearing material meets the loss-on-ignition criterion after calcination it is deemed suitable for storage. The standard does not impose a limit on the amount or type of aggressive compounds (salts) remaining after the stabilization process. It is expected that the plutonium-bearing material will contain chloride salt compounds.

Ga diffusion into the austenitic stainless steel container is likely during fifty-year storage. In order to ensure the integrity of the inner container we must understand the effect of gallium alloying on the corrosion behavior of 316 SS. The corrosion behavior can be evaluated by aqueous electrochemistry techniques using electrolytes that approximate the conditions at the liquid metal interface. For this study a potentiodynamic polarization technique was used.

Experimental Procedure

304L SS ingots alloyed with different amounts of gallium were cast. As-received material was cast in a similar manner for use as a control (0 wt% Ga samples). The

selected weight percent Ga in the 304L SS was 1%, 3% and 12%. The corrosion coupons were encased in epoxy and ground to 600 grit finish. The polished samples were rinsed with ethanol and distilled water. The exposed metal epoxy interface was covered with electroplating tape to minimize the possibility of crevice corrosion. The exposed metal surface was 0.2 cm^2 . Following ASTM standards all the samples were prepared no more than one hour before testing began². The 3M NaCl electrolyte solution was made with reagent grade chemicals and deionized water. Argon was bubbled through the solution one hour prior to and during the electrochemical measurements.

Various commercially-available, computer-controlled potentiostats were used to perform the electrochemical measurements. The electrochemical cell was a 500 ml five neck flask with a saturated calomel reference electrode and a platinized mesh counter electrode. The distance between the flat working electrode surface and counter electrode was 2 cm. Positive argon pressure was maintained in the corrosion cell. The corrosion samples were immersed in the electrolyte and the open circuit potential was monitored. Once the open circuit potential stabilized (one hour) the potentiodynamic polarization test began with a scan rate of 0.1 mV/s .

Results

The corrosion behavior of the alloys exposed to the NaCl electrolyte was assessed using the potentiodynamic polarization technique. The technique applies an overpotential at a rate of 0.1 mV/s and measures the resulting characteristic current. Near the open circuit potential the different composition alloys behaved similarly and corrode uniformly (Figure 1-4). The same behavior was observed in the passive region. The pitting tendency of the different alloys was evaluated by comparing the pitting potential and the repassivation potential (Table 1). The pitting potential is the potential at which metastable pits cease to repassivate leading to rapid material dissolution. This is reflected in the rapid increase of current several orders on magnitude larger than the passive current. Statistical analysis of replicate test, four for each composition, suggest that there is no significant difference in the pitting potential. Analysis of the repassivation potential, the potential below which pits do not propagate (i.e., the potential where

reverse scan intersects forward scan), also showed no statistically significant difference. However it must be pointed out that data for the 12 wt% Ga alloy were insufficient to make a valid evaluation of the repassivation potential.

In summary, the addition of up to 12 wt% Ga to 304L SS does not appear to have a significant effect on the corrosion behavior 304L SS exposed to NaCl solutions.

This work was supported by EM66 Nuclear Materials and Stabilization Program Office, United States Department of Energy, Albuquerque Operations and Headquarters Office, under the auspices of the DNFSB 94-1 Research and Development Project.

Material	Pitting Potential (mV _{SCE})	Repassivation Potential (mV _{SCE})
Control sample	144	-157
1 wt% Ga	177	-233
3 wt% Ga	212	-220
12 wt% Ga	179	

Table 1. Repassivation and Pitting Potentials for 304L SS exposed to deaerated 3M NaCl

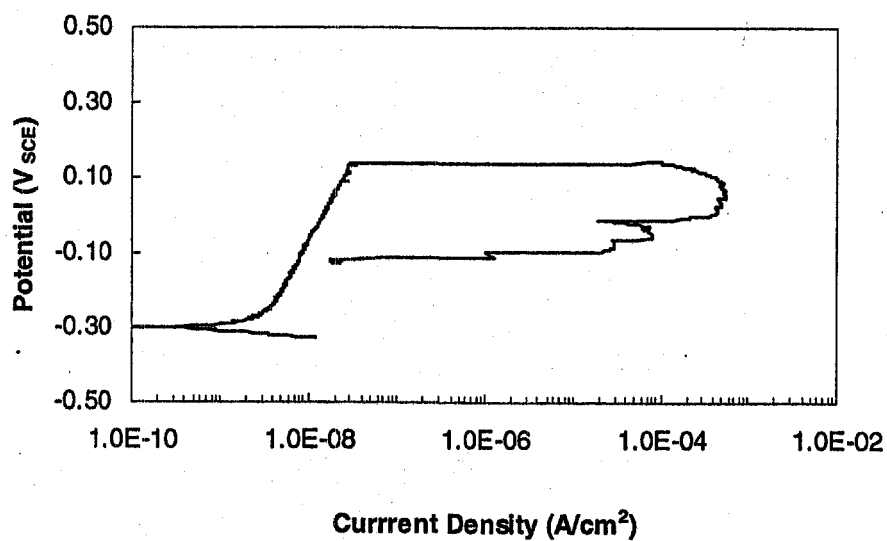


Figure 1. Polarization behavior of 316 SS in 3 M NaCl.

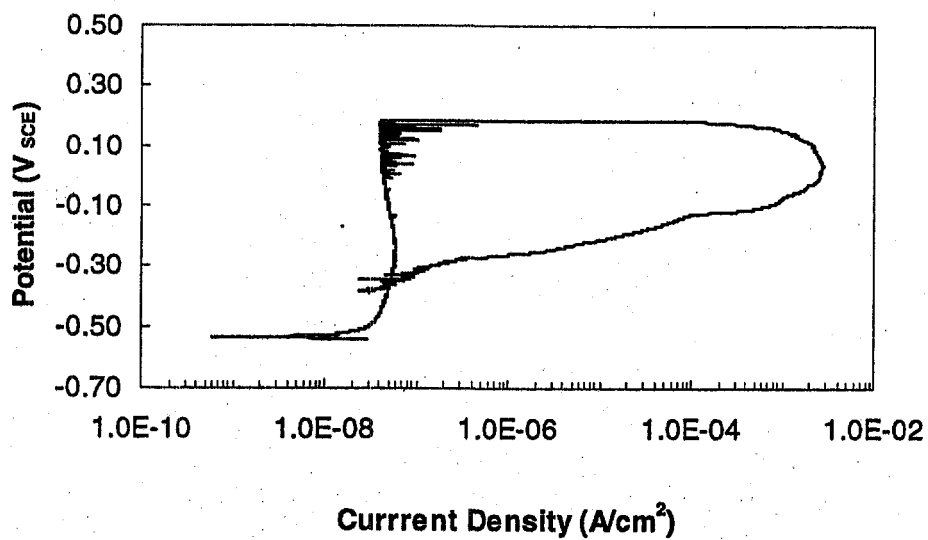


Figure 2. Polarization behavior of 1wt% Ga-316 SS in 3 M NaCl.

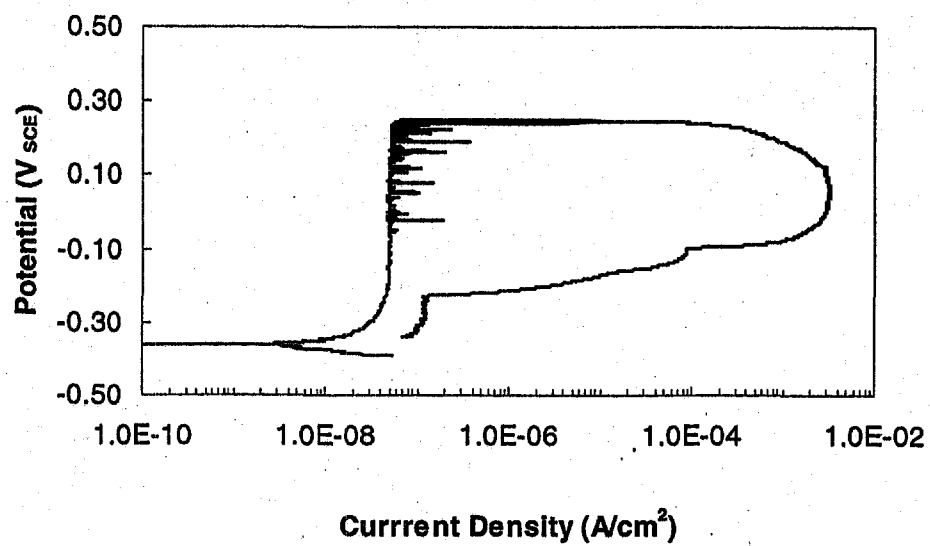


Figure 3. Polarization behavior of 3 wt% Ga-316 SS in 3 M NaCl.

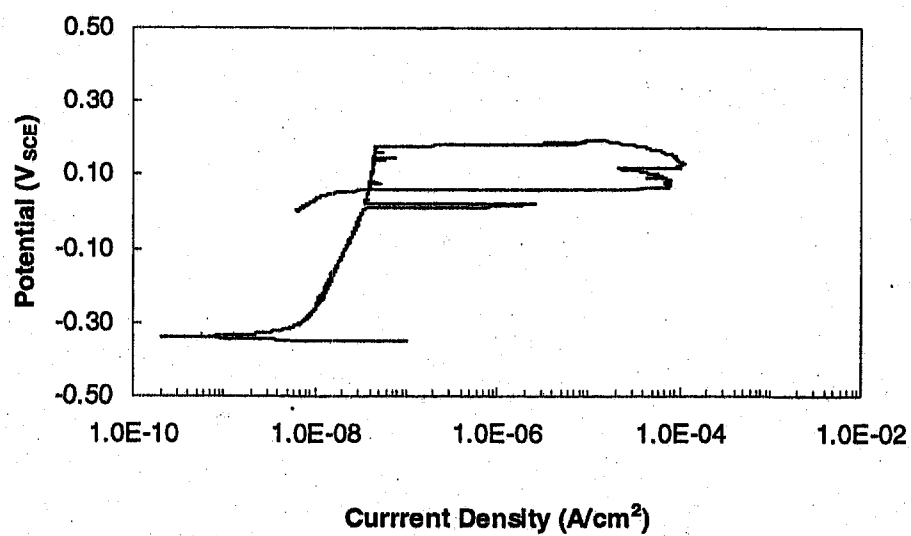


Figure 4. Polarization behavior of 12 wt% Ga-316 SS in 3 M NaCl.

- 1) D. G. Kolman, "An Assessment of the Corrosion, Stress Corrosion Cracking, and Embrittlement Susceptibility of 3013 Storage Containers", Los Alamos National Laboratory, Report LA-UR-98-5762, December 1998.
- 2) "Annual Book of ASTM Standards", vol. 3.02, ASTM, Philadelphia, PA.